

## 4-5 Determinants

The determinant of a matrix is a value of a square matrix that will be used to:

- calculate the inverse of a matrix
- solve systems

2x2 Matrix (2nd order determinants)  
The determinant, D, is calculated as follows:

$$D = \begin{vmatrix} a & b \\ c & d \end{vmatrix} = ad - bc$$

ex:

$$\begin{vmatrix} 5 & 10 \\ 8 & 3 \end{vmatrix} = -15 - 80 = -95$$

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ex:

$$\begin{vmatrix} -2 & 6 \\ -5 & 1 \end{vmatrix} = 28$$

ex:

$$\begin{vmatrix} 4 & 10 \\ 2 & 5 \end{vmatrix} = 0$$

$-2 \times 1 = -2$   
 $-2 \times -30 = -2 + 30$

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ex:

$$\begin{vmatrix} 4 & 6 \\ x & 12 \end{vmatrix} = 12$$

$$48 - 6x = 12$$

$$-6x = -36$$

$$x = 6$$

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3x3 Matrix (3rd order determinants)  
Before calculating the determinant, D, we must define a minor.

Minor--of an element in a determinant is the determinant resulting from the deletion of the row and column containing the element.

ex:

$$\begin{vmatrix} 5 & -1 & -2 \\ 3 & 6 & -7 \\ 2 & -3 & 4 \end{vmatrix}$$

The minor of 5 is:

$$\begin{vmatrix} 6 & -7 \\ -3 & 4 \end{vmatrix}$$

The minor of 6 is:

$$\begin{vmatrix} 5 & -2 \\ 2 & 4 \end{vmatrix}$$

The minor of -7 is:

$$\begin{vmatrix} 5 & -1 \\ 2 & -3 \end{vmatrix}$$

Evaluate the determinant, using expansion by minors.

ex:

$$\begin{vmatrix} 5 & -1 & -2 \\ 3 & 6 & -7 \\ 2 & -3 & 4 \end{vmatrix}$$

$$\begin{aligned} &+5 \begin{vmatrix} 6 & -7 \\ -3 & 4 \end{vmatrix} - (-1) \begin{vmatrix} 3 & -7 \\ 2 & 4 \end{vmatrix} + (-2) \begin{vmatrix} 3 & 6 \\ 2 & -3 \end{vmatrix} \\ &\quad \quad \quad \begin{matrix} 5(3) & + (1)26 & -2(-21) \\ 15 & + 26 & + 42 \end{matrix} \\ &\quad \quad \quad = 83 \end{aligned}$$

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$$\begin{vmatrix} + & - & + \\ - & + & - \\ + & - & + \end{vmatrix}$$

Evaluate the determinant, using expansion by minors.

ex:

$$\begin{vmatrix} 2 & -1 & -6 \\ 3 & 4 & 2 \\ 5 & -2 & 3 \end{vmatrix}$$

$$\begin{aligned} &-3 \begin{vmatrix} -1 & -6 \\ 4 & 2 \end{vmatrix} + 4 \begin{vmatrix} 2 & -6 \\ 5 & 3 \end{vmatrix} - 2 \begin{vmatrix} 2 & -1 \\ 5 & -2 \end{vmatrix} \\ &\quad \quad \quad \begin{matrix} -3(-19) & + 4(36) & -2(1) \\ 45 & + 144 & -2 \end{matrix} \\ &\quad \quad \quad = 187 \end{aligned}$$

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Evaluate the determinant, using expansion by minors.

ex:

$$\begin{vmatrix} 5 & 2 & 34 \\ -1 & 3 & 22 \\ 0 & 0 & 4 \end{vmatrix}$$

$$+0 \begin{vmatrix} 1 & -0 \end{vmatrix} - 0 \begin{vmatrix} 1 & +4 \end{vmatrix} + 4 \begin{vmatrix} 5 & 2 \\ -1 & 3 \end{vmatrix} = 4(15) = 60$$

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Expansion by minors works for any higher order determinant as well.

ex:

$$\begin{vmatrix} 1 & 2 & 1 & 0 \\ 3 & 2 & 1 & 1 \\ 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 2 \end{vmatrix}$$

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